TECHNICAL ANALYSIS OF POTENTIAL INTERFERENCE CAUSED TO MOBILE SATELLITE SERVICE FEEDER UPLINKS DUE TO NII/SUPERNET TRANSMISSIONS

Introduction

This analysis examines the potential for transmissions from unlicensed terminals operating in the proposed NII/SUPERNet Service to interfere with Mobile Satellite Service (MSS) Feeder Uplinks.

The material provided here presents an assessment of the interference from the proposed NII/SUPERNet Service which is based upon the level of interference that GLOBALSTAR feels is acceptable from an unlicensed Service, disputes the claim made in a flawed analysis from the Radiocommunication Sector of the International Telecommunications Union (ITU) that sharing is possible between High Performance Radio Local Area Networks (HIPERLANs) and MSS Feeder Uplinks and provides an EIRP density that will allow the NII/SUPERNet Service to share frequencies with MSS Feeder Uplinks.

Background

As envisioned in the instant NPRM, NII/SUPERNet is an unlicensed service for the purpose of providing computer-to-computer communication via the Internet. This communication will be provided by wireless means and will accommodate transmission rates ranging from a few kilobits per second to many megabits per second. The NPRM suggests that these transmissions will have a range on the order of 100 meters.

The following analysis is based on information in the NPRM. There is insufficient information in the NPRM to determine the method of operation that will be used for the proposed NII/SUPERNet devices. It is unclear whether each NII/SUPERNet device will act as a repeater for transmissions from other computers or whether there will be strategically located "supernodes" that will act as receivers and transmitters for transmissions from the individual computer nodes. It is evident that the NII/SUPERNet system must be connected to the Internet at some point but it is unclear whether this connection will be made through a wireless air interface or through a "wired" interface. Information such as this has a bearing on the analysis of potential interference, but has not been clarified in the NPRM.

The Commission has suggested allocations of 350 MHz at 5150 - 5350 MHz and 5725 - 5875 MHz. The Commission has further suggested a maximum transmitter power of 100 milliwatts or -10 dBW, with a maximum EIRP density of

0.03 milliwatts per 3 kHz, for this service and restricted outdoor antenna heights, generally, to 15 meters or less.

Assessment of Acceptable Interference

The GLOBALSTAR System plans to operate Feeder Links, that is links from Gateway earth stations to GLOBALSTAR spacecraft, in the 5091 - 5250 MHz band that was recently allocated at WRC'95. The band 5150 - 5250 MHz is suggested in this NPRM for use by NII/SUPERNet service. GLOBALSTAR maintains that the simultaneous use of this band by both MSS Feeder Links and NII/SUPERNet is incompatible based on the technical parameters proposed in the NPRM. This incompatibility stems from the power level and potential number of the proposed NII/SUPERNet users. Transmissions from a relatively small number of NII/SUPERNet users will produce sufficient interference to interfere with the GLOBALSTAR Feeder link transmissions in this band. Transmissions from the proposed NII/SUPERNet system will have nearly the same effect as thermal noise on transmissions in the GLOBALSTAR System. Any interference on the Feeder Uplink will produce a decrease in quality of the service link transmissions or a decrease in the number of service links. The extent of the reduction in quality or capacity is a complex function of the interference level, the demand on satellite power resources, the satellite constellation geometry and other factors.

It is assumed at the outset that, as stated in the NPRM, the maximum EIRP from an NII/SUPERNet user is limited to -10 dBW with a maximum EIRP density of 0.03 milliwatts per 3 kilohertz of signal bandwidth. This density corresponds to -10 dBW being uniformly spread over a 10 MHz bandwidth. The analysis presented here is based upon NII/SUPERNet users emitting a uniform spectrum over the suggested bands at the maximum EIRP density of 0.03 milliwatts per 3 kHz of signal bandwidth without regard to the total signal bandwidth. Thus, if less than 10 MHz of bandwidth were used, the power emitted by a single user would be proportionally less than -10 dBW.

Since the proposed NII/SUPERNet devices will be Part 15 unlicensed devices, they are precluded from causing interference to and must accept interference from licensed Services. Recognizing that any interference to an MSS system Feeder Uplink will cause a degradation, GLOBALSTAR asserts that the total acceptable interference due to NII/SUPERNet be limited to an increase in Feeder Uplink noise density of 0.1%. This is referred to as 0.1% delta T/T. Delta T/T is used by the International Telecommunications Union (ITU) as a measure of interference to determine whether coordination between systems is required. The trigger for coordination with co-primary Services used by the ITU is 6% delta T/T. The instant analysis uses a 0.1% delta T/T as a measure of the level of interference should be absorbed from the unlicensed Service. This amount of interference is considered long term interference that will always be present. The

assumption of long term, nearly constant interference is valid given that it is expected that there will be a large number of users of the NII/SUPERNet service. It is further expected that the maximum usage of the NII/SUPERNet will coincide with the busiest period of usage of the GLOBALSTAR System over the USA and hence the Feeder links of the System will be stressed to the maximum.

The Iso-Flux nature of the GLOBALSTAR spacecraft 5 GHz receive antenna is such that the gain of this antenna varies so that an equivalent amount of receive power is present at the output of the antenna regardless of the magnitude of the slant range from the emitter on the surface of the earth to the spacecraft. This antenna quality implies that an equivalent amount of interference will be received from any point on the earth that is within the coverage of the antenna. The attenuation between a user on the earth's surface and the spacecraft antenna is calculated as follows:

PL = 20 log(lambda/4*PI*SR)

where: lambda = signal wavelength, 5 GHz=> 0.058 meters;

PI = 3.14159...;

SR = Slant Range = 1414 kilometers. The Iso-Flux nature of the GLOBALSTAR 5 GHz receive antenna makes the Slant Range appear constant regardless of the location of the interferer within the receive antenna coverage. The resulting attenuation due to this spacecraft altitude is 169.7 dB.

The GLOBALSTAR spacecraft receive antenna has a gain of 1 dBi at nadir.

The EIRP density due to a single NII/SUPERNet user is 0.03 milliwatts per 3 kHz or -45.3 dBW/3 kHz. This amount of power emitted at the earth's surface implies that the received interference at the GLOBALSTAR spacecraft will be - 214.0 dBW/3 kHz per user (Interference Power Density - Path Loss + Spacecraft Antenna Gain).

Using the 0.1% delta T/T interference criterion, the acceptable interference at the GLOBALSTAR spacecraft is calculated, for a nominal value of T=1000K, as follows:

delta T/T = delta T/receive system noise temperature

delta T = delta T/T * receive system noise temperature

receive system noise temperature,T = 1000K => 30 dB-K

delta T = 0.001*1000 = 1K => 0.0 dB-K.

Thus the total interference power from all NII/SUPERNet users must be 30 dB below the GLOBALSTAR receive system noise or -193.7 dBW/3 kHz. Using the results of the interference power calculation above, the interference power density from a single NII/SUPERNet user is -214 dBW/3kHz or 20.3 dB (107 numeric) below the limit for acceptable interference to the GLOBALSTAR Feeder Uplink.

The ITU specifies power density for digital communications carriers referenced to a bandwidth of 1 MHz. Applying this convention to the proposed NII/SUPERNet Service results in a transmitted EIRP density, per device, of -20.1 dBW/MHz which is equivalent to 0.03 milliwatts per 3 kHz.

As an example, assume that a typical NII/SUPERNet user will use 10 MHz of spectrum during a transmission and thus an EIRP of -10 dBW. This implies simultaneous use by ten users of 100 MHz of spectrum in the 5150 - 5250 MHz segment. Since the EIRP density of a single user is 20.3 dB below the GLOBALSTAR threshold for acceptable interference, approximately 107 times the number of transmitters may be simultaneously activated before this threshold is surpassed. Thus 1070 users may be simultaneously accommodated across the 100 MHz bandwidth assuming 10 MHz of bandwidth per user. The receive antenna of a single GLOBALSTAR spacecraft can easily cover the entire area of the USA, 3.6 million square miles. Therefore, in the continental USA only 1070 NII/SUPERNet users could uniformly access the service at one time before reaching an EIRP density level at which unacceptable interference occurs.

If each user were to require a smaller bandwidth, proportionately more users could be accommodated but true multi-media access to the Internet will require the usage of approximately 10 MHz of bandwidth by a single user. As the usage of the Internet by NII/SUPERNet users becomes more sophisticated, the capacity available, while still meeting interference requirements, will approach the number given above.

Since the NII/SUPERNet service will be unlicensed, it will be difficult to regulate the number of users and, therefore, nearly impossible to regulate the amount of interference that would be generated by the devices in use. In order to stay within acceptable interference limts to the GLOBALSTAR System it would be necessary to restrict the power output of single users in the 5150 - 5250 MHz band to well below the 100 milliwatts or -45.3 dBW/3 kHz suggested in the NPRM. It is not beyond the realm of possibility to envisage one million simultaneous users of the NII/SUPERNet service taking into account the predictions of the proponents. This number of users would imply a reduction in the proposed transmitter power by at least 30 dB, a factor of 1000, to limit interference to the GLOBALSTAR

system. The accommodation of more than one million users implies a concomitant reduction in transmitter power.

ITU-R HIPERLAN Sharing Analysis

The instant NPRM references conclusions based on an analysis of the effects of interference on MSS Feeder Uplinks from High Performance Radio Local Area Networks (HIPERLANs) which was included in a Report of the deliberations of ITU-R Task Group 4/5 which considered the sharing of frequency bands between MSS Feeder Links and other radio Services. The conclusions of this group were included in text proposed for the Conference Preparatory Meeting (CPM) Report of 1995.

The Service proposed in the NPRM has characteristics similar to HIPERLANs. With respect to the GLOBALSTAR System, the analysis contained in the Task Group 4/5 report greatly underestimates the effect of interference from HIPERLANs to GLOBALSTAR Feeder uplinks. In ITU-R terminology, the LEO-D System closely resembles GLOBALSTAR. The specific analysis is contained in ITU-R Document 4A/66 which is dated 10 February 1995 on pages 131-132 and 158-165.

The ITU-R analysis determines the maximum tolerable number of active, outdoor HIPERLAN nodes to be 95000 in one HIPERLAN channel which is 24 MHz in width. This number is based on a Gateway earth station EIRP of 51.1 dBW and an allowable Carrier-to-Interference ratio (C/I) of 15 dB. The ITU-R analysis assumes an incorrect earth station EIRP for a GLOBALSTAR-like system and an overly permissive interference allotment of 15 dB C/I. An analysis that uses correct figures would indicate a much lower number of active, outdoor HIPERLAN nodes that could operate before producing unacceptable interference to MSS Feeder uplinks.

The value used for Gateway Station uplink EIRP in the ITU-R analysis is 51.1 dBW. The value listed in Table 1 "Technical Characteristics of Feeder Links for Some Proposed Non-GSO MSS Systems" on page 9 of the Report, gives a value for the LEO-D System (GLOBALSTAR) of 54 dBW which is a composite value for all of the CDMA carriers that could use an uplink channel. This value was included in Table 1 for use in determining the effects of interference from the LEO-D system into other systems. It is not clear why a value of 51.1 dBW was assumed for the interference analysis. The nominal value for the GLOBALSTAR Gateway Station uplink EIRP is 27 dBW per user which is the value contained in the modification application for GLOBALSTAR that was filed with the Commission in March 1996. Using 27 dBW to calculate the number of active,

outdoor HIPERLAN nodes would reduce the calculated number by a factor of at least 250.

The ITU-R analysis takes into account the path loss difference due to the HIPERLAN transmitter being located at the sub-satellite point and the Gateway Station being located near the edge of the satellite coverage and transmitting at an elevation angle of 5 degrees. Due to the use of a quasi "Iso-Flux" receive antenna on the GLOBALSTAR spacecraft, there is little difference in receive power at the spacecraft receiver of signals emanating from anywhere within the antenna coverage area. Thus the 8.8 dB used in the analysis to reflect the path loss difference is incorrectly applied and should be considered to be 0 dB.

Another flaw in the ITU-R analysis is the assumption that allowable interference from HIPERLANs could be equivalent to a C/I of 15 dB. On pages 26 and 27 of Document 4A/66, it states that Task Group 8/3, which determined MSS Feeder Link requirements, proposed a single entry interference criteria for Feeder Links in the 4 - 8 GHz range of 3% of the total Feeder Link noise for co-primary systems sharing the Feeder Link frequency band. This implies a Io/No of -15 dB rather than a C/I of 15 dB. It should be noted that when making this proposal, Task Group 8/3 was considering interference from other licensed, co-primary Services and not unlicensed, secondary Services. GLOBALSTAR considers both a C/I of 15 dB and an Io/No of -15 dB to be inadequate for the protection of licensed Feeder link transmissions from secondary Services. An appropriate value of Io/No for the protection of MSS Feeder uplinks from unlicensed services is - 30 dB as indicated by the delta T/T of 0.1% in the analysis given above. Thus the use of a reasonable interference criterion in the ITU-R HIPERLAN analysis would lead to the number of active, outdoor HIPERLAN nodes being even further reduced.

Further, the ITU-R analysis extends the number of allowable active, outdoor nodes to a total number of nodes by assuming that there would be three HIPERLAN channels, a ratio of active to inactive terminals of 100 and a ratio of indoor to outdoor terminals of 100. This extension assumes that there would be no interference due to indoor terminals because of attenuation of the HIPERLAN signal by the building. This is unrealistic since it would be impossible to regulate whether a terminal was deployed indoors or outdoors and the amount of attenuation would vary from building to building. Situating a HIPERLAN terminal near a window would lead to far less building attenuation than situating a terminal in a building basement. The extension of the allowable number of active, outdoor HIPERLAN nodes contained in the ITU-R is optimistic and unrealistic considering actual operating conditions. In summary, the ITU-R analysis is significantly flawed and does not support the proposals made in the instant NPRM.

Summary and Conclusions

The foregoing technical analysis indicates that the co-existence of MSS Feeder Uplinks and NII/SUPERNet systems in the band 5150 - 5250 MHz is not feasible given the proposed characteristics of the unlicensed Service. Adoption of the proposed characteristics will result in unacceptable amounts of interference to MSS Feeder uplinks.

It has further pointed out errors in the ITU-R analysis of sharing between HIPERLANs and MSS Feeder Uplinks that was referenced in the instant NPRM.

Better definition of the NII/SUPERNet systems may point the way to possible sharing strategies but the present information indicates that sharing of the frequency band between the MSS Feeder Links and the NII/SUPERNet system is not feasible.

GLOBALSTAR maintains that the maximum amount of interference that can be absorbed from an unlicensed Service operating co-frequency with an MSS Feeder uplink must be limited to an interference level equivalent to an Interference Power Density-to-Receive System Noise Power Density ratio (Io/No) of -30 dB. This is equivalent to a delta T/T of 0.1%, as used in the analysis above.

Based upon this level of acceptable interference, in order for sharing to be feasible between an unlicensed NII/SUPERNet Service and MSS Feeder Uplinks, the aggregate EIRP density of the entire NII/SUPERNet Service including all of the users over a 3 million square mile area must not exceed 0 dBW/MHz over any one MHz in the 5150 - 5250 MHz band at any instant in time.

This aggregate EIRP density is derived as follows. As stated above, the acceptable total interference power from all NII/SUPERNet users must be at least 30 dB below the GLOBALSTAR receive system noise temperature of 1000K. This level was shown to be -193.7 dBW/3kHz which is equivalent to -168.5 dBW/MHz. It was also shown above that the combined path loss from the earth to the spacecraft and the 5 GHz antenna gain of the GLOBALSTAR spacecraft is 168.7 dB. The NII/SUPERNet Service aggregate EIRP for acceptable interference is then:

$EIRPo_{AGGREGATE}$ = Acceptable Interference + Composite Loss Density @ Spacecraft Receiver

$EIRPo_{AGG}$ = -168.5 dBW/MHz + 168.7 dB = 0.2 dBW/MHz

which is approximately 0 dBW/MHz.

Taking into account the Iso-Flux nature of the GLOBALSTAR 5GHz receive antenna mentioned above, the spacecraft effectively receives over a surface area exceeding 3 million square miles; therefore, the aggregate EIRP density over this area should not exceed 0 dBW/MHz over any one MHz across the 5150 - 5250 MHz band at any instant in time in order to restrict the delta T/T increase to 0.1%.

DECLARATION

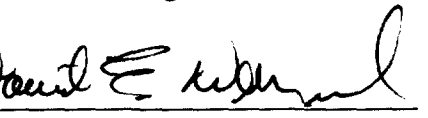
1. I, David E. Weinreich, am a Technical Consultant to Globalstar.

2. I am familiar with the original Globalstar™ application filed with the Federal Communications Commission on June 3, 1991, and the amendments to this application filed on November 16, 1994, and March 8, 1996. I am also familiar with Parts 2, 15 and 25 of the Commission's Rules and the rules and policies proposed for the NII/SUPERNet service in the Notice of Proposed Rule Making released May 6, 1996.

2. I have prepared the foregoing "Technical Analysis" and the information presented therein is accurate.

I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge and belief.

Signed this 15th day of July 1996 in Washington, D.C..



David E. Weinreich
Technical Consultant
Globalstar, L.P.

CERTIFICATE OF SERVICE

I, William D. Wallace, hereby certify that I have on this 15th day of July 1996, caused copies of the foregoing Comments of L/Q Licensee, Inc. to be delivered via hand delivery (indicated with *) or by U.S. mail, postage prepaid, to the following:

*Chairman Reed E. Hundt
Federal Communications Commission
1919 M Street, N.W.
Room 814
Washington, D.C. 20554

*Commissioner James H. Quello
Federal Communications Commission
1919 M Street, N.W.
Room 803
Washington, D.C. 20554

*Commissioner Susan Ness
Federal Communications Commission
1919 M Street, N.W.
Room 832
Washington, D.C. 20554

*Commissioner Rachelle B. Chong
Federal Communications Commission
1919 M Street, N.W.
Room 844
Washington, D.C. 20554

*William E. Kennard
General Counsel
Federal Communications Commission
1919 M Street, N.W.
Room 614
Washington, D.C. 20554

*Donald H. Gips
Chief
International Bureau
Federal Communications Commission
Suite 800
2000 M Street, N.W.
Washington, D.C. 20554

*William Bell
International Bureau
Federal Communications Commission
2000 M Street, N.W.
Room 888
Washington, D.C. 20554

*Thomas Tycz
Chief, Satellite & Radio
Communications Division
Federal Communications Commission
Suite 800
2000 M Street, N.W.
Washington, D.C. 20554

*Cecily C. Holiday
Deputy Chief, Satellite & Radio
Communications Division
Federal Communications Commission
2000 M Street, N.W., Suite 800
Washington, D.C. 20554

*Fern J. Jarmulnek
Chief
Satellite Policy Branch
Federal Communications Commission
2000 M Street, N.W., Room 500
Washington, D.C. 20554

*Karl Kensinger
International Bureau
Federal Communications Commission
Suite 521
2000 M Street, N.W.
Washington, D.C. 20554

*Bruce Franca
Office of Engineering and Technology
Federal Communications Commission
2000 M Street, N.W.
Room 480
Washington, D.C. 20554

*Michael J. Marcus
Office of Engineering and Technology
Federal Communications Commission
2000 M Street, N.W.
Room 480
Washington, D.C. 20554

*Fred Thomas
Office of Engineering and Technology
Federal Communications Commission
2000 M Street, N.W.
Room 480
Washington, D.C. 20554

*Charles Iseman
Federal Communications Commission
2000 M Street, N.W.
Room 480
Washington, D.C. 20554

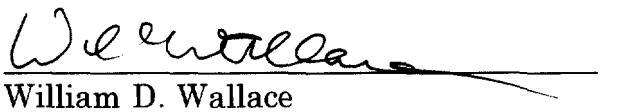
*Richard M. Smith, Chief
Office of Engineering and Technology
Federal Communications Commission
2000 M Street, N.W.
Room 480
Washington, D.C. 20554

*Thomas Derenge
Office of Engineering and Technology
Federal Communications Commission
2000 M Street, N.W.
Room 432
Washington, D.C. 20554

*Harry Ng
International Bureau
Federal Communications Commission
2000 M Street, N.W.
Room 512
Washington, D.C. 20554

R. Michael Senkowski
Eric de Silva
Wiley Rein & Fielding
1776 K Street, NW.
Washington, D.C. 20006

Henry Goldberg
Goldberg Godles Wiener & Wright
1229 19th Street, N.W.
Washington, D.C. 20036



William D. Wallace